

Los Alamos

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memorandum

TO: Distribution

DATE: November 12, 1981

FROM: Morton C. Smith *ms*

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SYMBOL: ESS-DOT

SUBJECT: USE OF A HYDRAULICALLY BULGED LINER FOR HYDRAULIC FRACTURING IN EE-2

At a recent meeting in the ESS Division Office, I protested vigorously against initiating an intensive program to develop hydraulically bulged liners for isolation of hydraulically fractured zones in HDR injection wells -- and specifically in EE-2 at Fenton Hill. I did not increase my popularity in some quarters by doing so (which was not my purpose), and I was neither opposing the advancement of science and technology nor exhibiting a "not-invented-here" complex. I was simply expressing a real doubt that such a system could be made to work; the feeling that its proponents had not yet identified all of its major problems; and the conviction that we could not afford the money or manpower which would be required to investigate those problems in the next few months or even years. Perhaps I was wrong about those things, and I do recognize many advantages in a liner bulged at intervals along its length--if it can indeed be installed and made to operate as its advocates believe it can. Therefore, for the consideration of interested parties, I will list and explain my major concerns about hydraulically bulged liners.

1. Materials. I assume that the material to be bulged would be a metal and that, on the bases of availability in the diameters, wall thicknesses, and lengths required of a liner, the properties required for insertion and bulging, electrochemical compatibility with other downhole equipment, and cost, it would be steel. It is traditional that material to be expanded hydraulically should be in the annealed ("dead-soft") condition and, while the local elongations that will occur in this case cannot be predicted accurately, they will be large--so that fully annealed material should certainly be specified. To avoid welds, the liner should be made from seamless tubing. (Even if it is chemically identical with the parent metal, a weld has a cast microstructure quite different from that of the rest of the tube and, even after heat treatment, can be expected to have different properties. It would be expected to elongate either more or less easily than the adjacent metal, with some effect on bulging behavior of the tube--which I can't predict. I also cannot predict the effect of the heat-affected zones adjacent to the weld, but assume that, to produce a good seal against the borehole wall, a uniform bulging behavior is important. I am not sure that that will be obtained even with high-quality, annealed, seamless tubing in large diameters, but that would certainly be the best available bet.)

Cy: J. Whetten
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Expanded Liner Tests (FY 82)

C

1. After all open hole tests (including possible bottom hole explosive test)

200K

MOB 35
4 wks 85
Pump 50
3rd 30
200

- Mobilize rig
- Set single section expanded liner (30 ft length) 30 ft off of existing hole bottom (see Fig. 1)
- Expand liner and then cut bottom opening *w/shape change*
- Test seal. Options if seal is not adequate:

1. Lost circulation material (LCM)
2. High explosive controlled expansion

- Attempt fracture connection (rented pumping equip) (one million gal limit) (option: use explosive stimulation if inlet impedance is too high) *There should be a reasonable flow (230 gpm) at 1500 psi injection pressure (See no 2 below)*
- Vent system and remove pressure string by cutting off (severing) above expanded liner

*

- Dismiss rig (If sealing could not be achieved, consider abandoning technique)

2. Rig EE-2 wellhead with *either Kobe or* Gould pumping and logging packoff.

- Reinject into bottom fracture(s) *enough flow for a period needed to cool the borehole to a temp level low enough to allow the* up to 1×10^6 gal and flow rate of ~~~100 gpm~~ *at the end of the measurement period;* with following sequence of logs during injection period:
 - a) Temp/Temp gradient - This will provide time when bottom hole temperatures are low enough to use any available logging tool (either ESS-6 or commercial)
 - b) Multi-arm caliper
 - c) Electric
 - d) Sonic
 - e) Temperature/Temp gradient (at or near end of injection to detect anomalies from Fisher/Aamodt process)

Fig. 2

- Vent

3. With information from above tests *logs* and expansion technique studies design a 3-port expandable liner to be set just above existing expanded metal packer. (Seal lengths and annuli lengths to be determined) (This system will incorporate and test existing state of art in sealing off sequential grown fracture systems) (Also provide for thermal contraction w/o/rig)

4. Mobilize rig (2nd time)

- Construct and set 3-port liner (Fig. 3)

- Expand System

- Dismiss Rig

- Perforate lower region and fracture (maximum injection $\sim 10^6$ gal.

MOB 35
2 wks 45
Pump 150
Add 20
250

TOTAL
500K

- . Seal off lower region and repeat above
- . Seal off middle region and repeat
(At this point success in the three pumping operations will have provided a 3-fracture system). (The characteristics of each fracture will be determined during the stimulation)
- . Set control system to provide access to all fractures and flow test total system.

Two methods for controlling flow in a downhole system during and possibly after fracturing.

1. Sliding Sleeve Valve

Each annular region formed by the selective expansion of the liner would have a carefully machined internal length into which is inserted a close fitting sleeve. In addition the machined length would be broached with an opening chosen to provide the following functions:

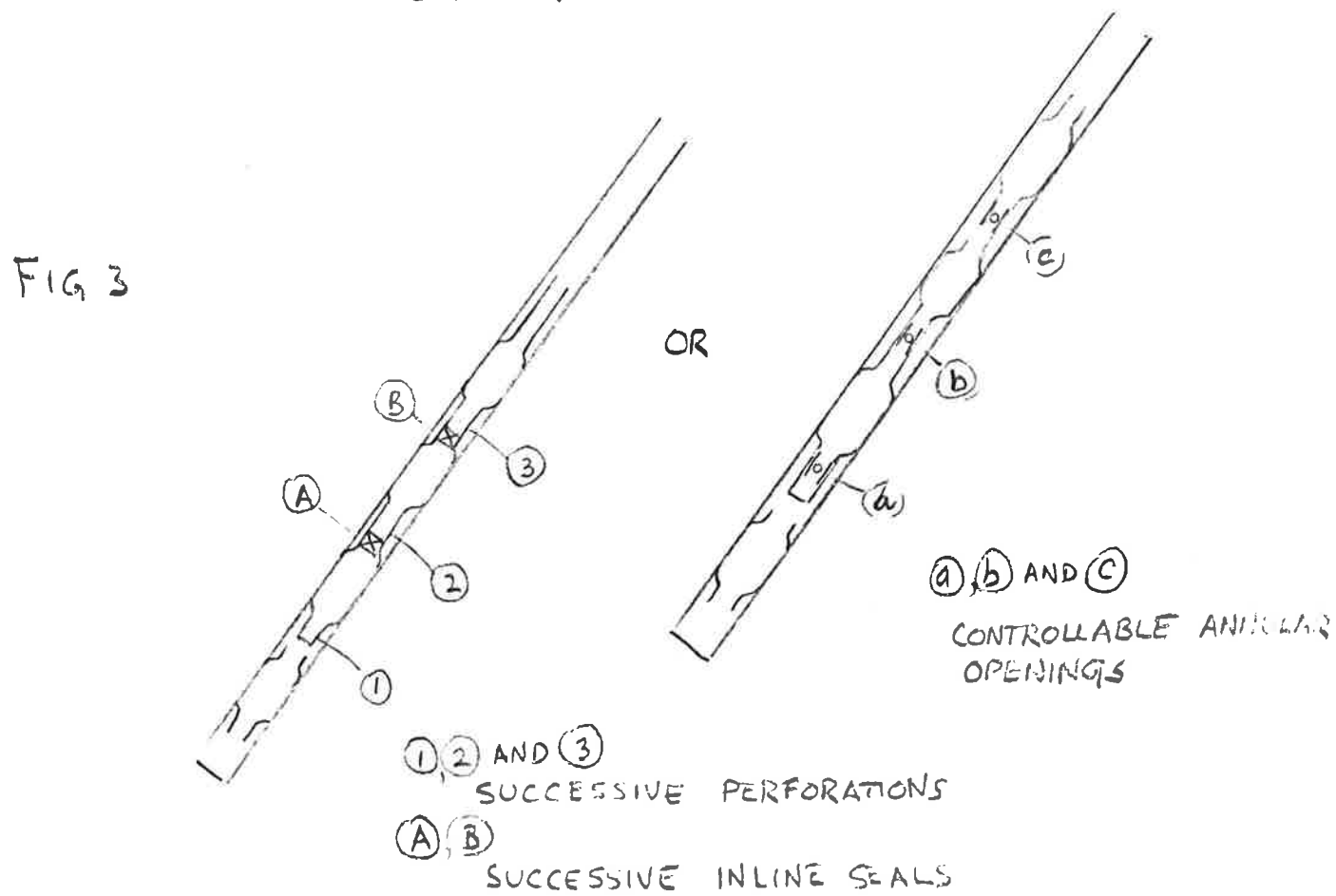
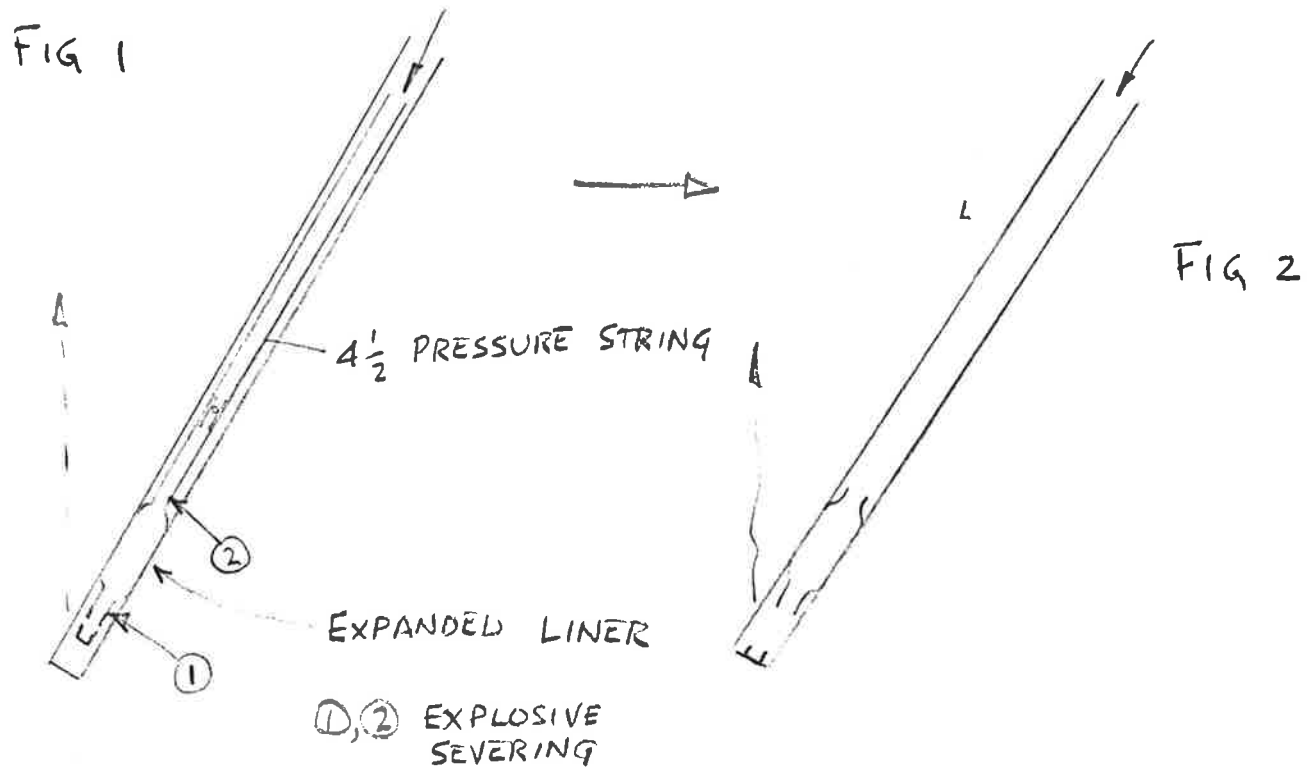
- . An area great enough to allow the flow of fluid needed for rapid fracture growth with low impedance across the opening.
- . A shape such that with movement of the covering sleeve a wide range of effective areas are allowed, from full opening to complete closure, thus resulting in complete inlet impedance control. (Fig. 4)

The thickness of the sleeve must be great enough to resist permanent deformation during the casing expansion. It would be moved into the desired position by impacts from a wireline tool. This tool must have the ability to expand an impacting mechanism so as to both pass through the sleeve and also to move either up or down.

Demonstration of such a mechanism would in principle provide the means for both creating and regulating a full size multi-fracture system. (Leakage could be controlled either through a close fit or stopped with end o-rings).

2. Wireline Inflatable Packer

Each annular region can be accessed by perforations. However to stimulate a specific zone all other perforated regions will be isolated. This can be achieved in a simple fashion by sequentially perforating from the bottom isolating each zone in turn with an inline seal. The following method for achieving this uses a slightly modified Lynes inflatable bridge plug driven by pressurized water from an intensifier which in turn is activated by pressurizing the frac string. When a predetermined pressure level is reached the packer sets preventing flow to the lower perforations and allowing



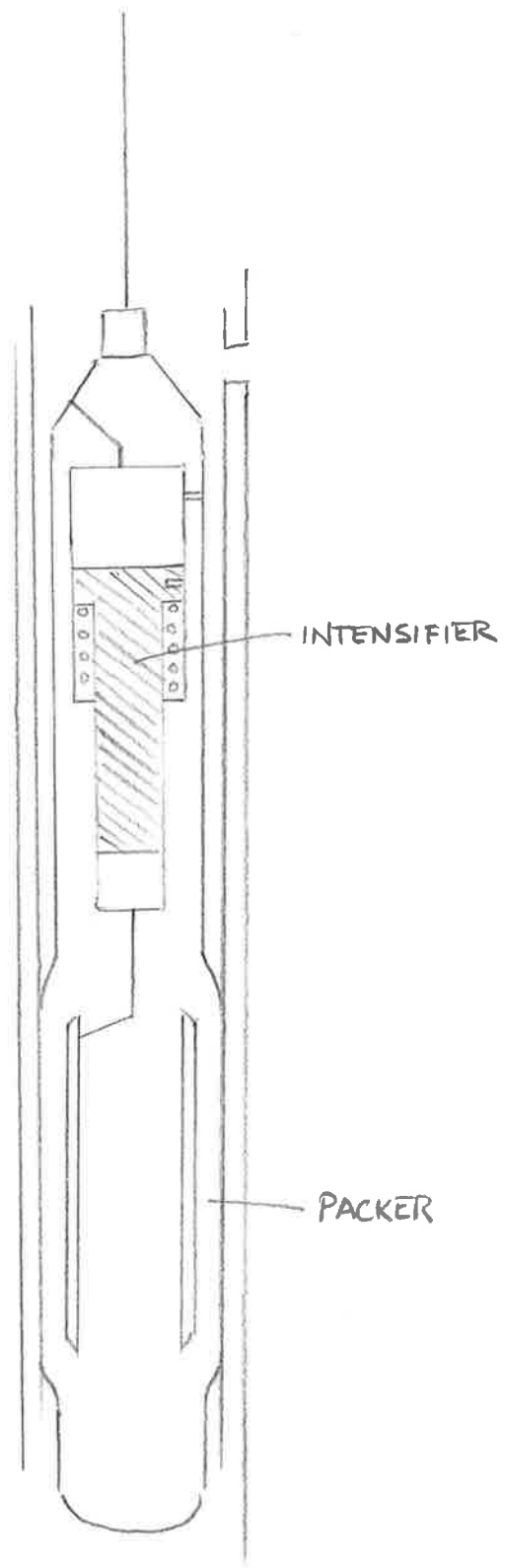
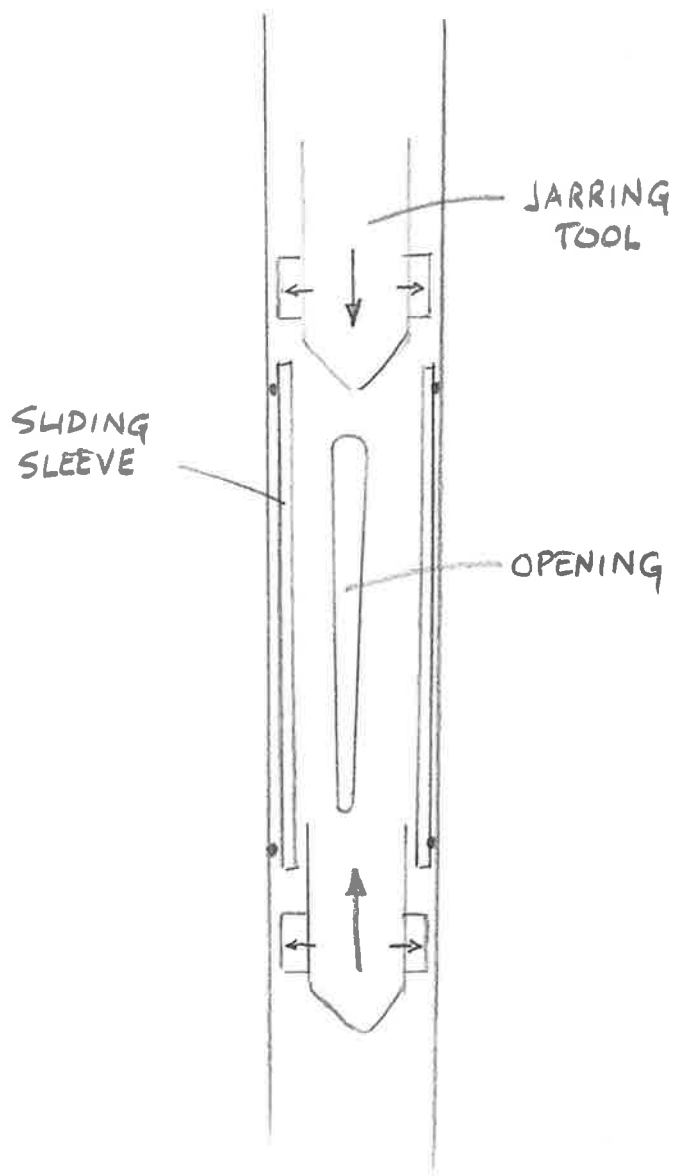


FIG 4

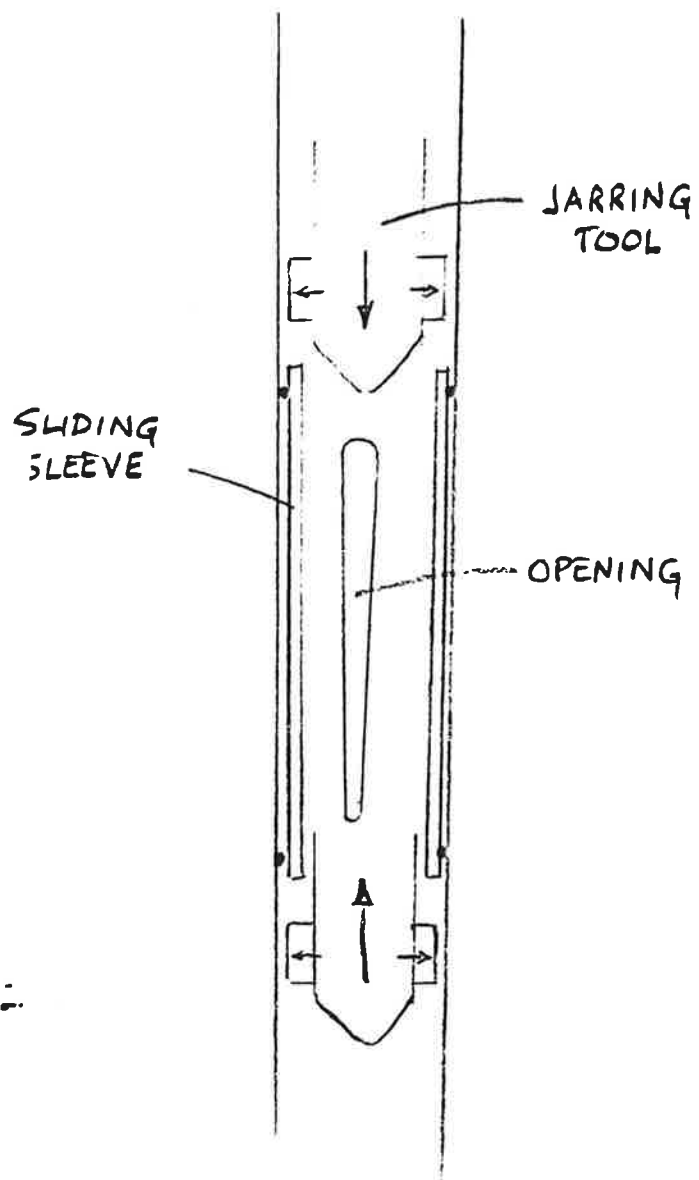
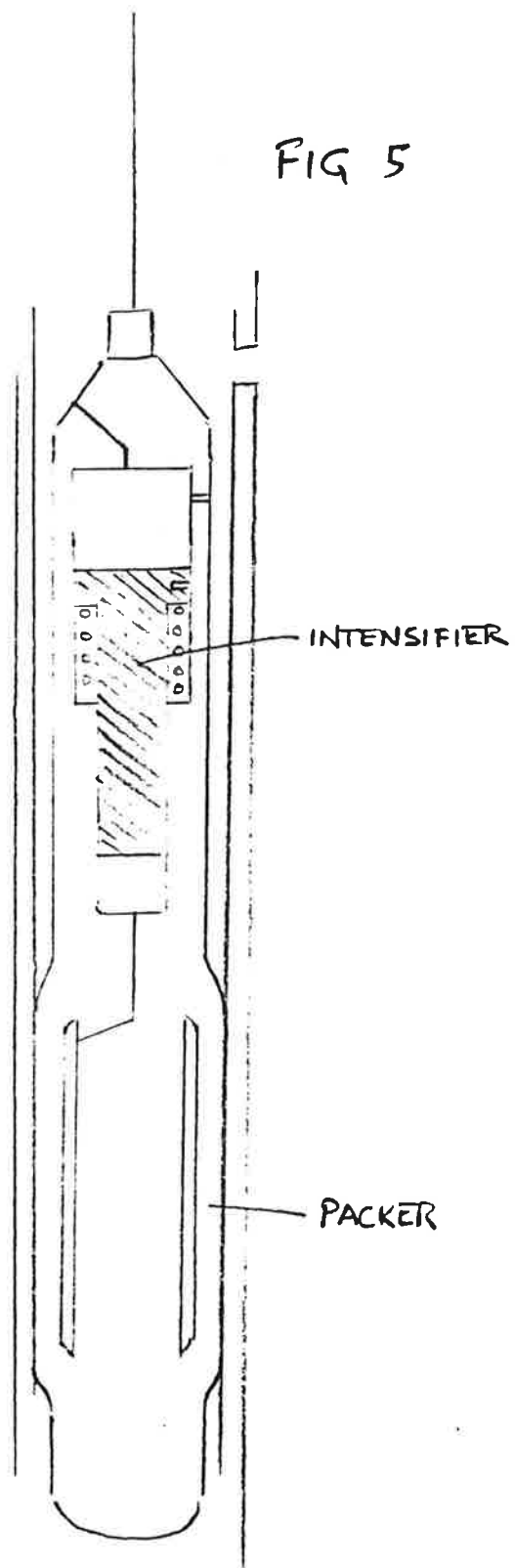


FIG 5



the creation and growth of a fracture from the highest perforated annular region. Termination of pumping followed by venting automatically releases the packer (Fig. 5).

Note

An adaption of this technique could be used with advantage in moving the sliding sleeve valve mentioned above. If a packer assembly could fit inside the sleeve, its inflation would firmly connect ^{it to the sleeve} to provide a mass which could be jarred either up or down with jarring links in the supporting cable.

DIRECTOR'S OFFICE
PERSONNEL

"IT'S LONELY AT THE TOP"

(BUT NOT AS LONELY AS IT USED TO BE)

